Bimodal Biometric System using Multiple Transformation Features of Fingerprint and Iris

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***Abstract*-The biometric technology is used to identify individuals effectively compared to existing traditional methods. In this paper we propose Bimodal Biometric System using Multiple Transformation features of Fingerprint and Iris (BBMFI). The iris image is preprocessed to generate iris template. The two level Discrete Wavelet Transformation (DWT) is applied on iris template and Discrete Cosine Transformation (DCT) is performed on second level low frequency band to generate DCT coefficients which results in features of iris. The fingerprint is preprocessed to obtain Region of Interest (ROI) and segmented into four cells. Then the DWT is applied on each cell to derive approximation band and detailed bands. The Fast Fourier Transformation (FFT) is applied on approximation band to compute absolute values that results in features of fingerprint. The iris features and fingerprint features are fused by concatenation to obtain final set of features. The final feature vector of test and database are compared using Euclidean distance matching. It is observed that the values of Total Success Rate (TSR), False Rejection Rate (FRR) and False Acceptance Rate (FAR) are improved in the proposed system compared to existing algorithm.**

***Index terms*- Fingerprint, Iris, DWT, DCT, FFT, Euclidean distance.**

I. Introduction

Automation in every field of daily life has made the need for mechanized human identification and verification is a prime issue for ensuring the security. Human identification and verification based on analysis of physiological or the behavioral information is referred to as biometric. The term biometric is also referred to as measurement of life. Since this technique realizes on features of the human body which is unique and cannot be stolen or need not be memorized. The biometric system is more secure compared to traditional methods such as PIN, passwords, security questions, ID badges and smart cards etc... [1]. Essential biometric can classify under two categories. (i) *Physiological parameters*. (ii) *Behavioral characteristics*. Based on requirement, different applications such as civilians, commercial, government offices, airports and banks, organizations [2, 3] make use of different biometric characteristics such as face, fingerprint, palm print, iris, DNA, retina, voice, signature, keystroke, etc. The commonly used biometrics is iris and fingerprint. The iris part of an eye is a coloured tissue surrounding the pupil, which in turn surrounded by a layer called cornea [4]. The iris is chosen due to high degree of randomness as no two iris are alike and remains stable throughout person's life. Fingerprint consists of sequence of ridges and valleys formed during fourth month of fetal development. Ridges are dark coloured and can be used for identification. Fingerprint can also be identified based on core, delta and minutiae [5]. Most of the biometric applications use unimodal and has disadvantages like noise in biometric data which results due to improperly maintained sensors and intra-class variation [6]. The limitations of unimodal usage can be minimized by using multimodal biometric systems [7]. A biometric-based authentication system operates in two modes [8]: (i) *Enrolment mode*: In this a user's biometric data is acquired using a biometric sensor and stored in a database. (ii) *Authentication mode:* In this a user's biometric data is acquired to either identify or verify the claimed identity of the user. It includes two phases (a) identification involves comparing the acquired biometric information against templates corresponding to all users in the database; (b) verification involves comparison with only those templates corresponding to the claimed identity. A multimodal biometric system can be built by the fusion of two or more biometric parameters. Fusion in the biometrics can be carried out in the following forms, (i) single biometric multiple feature fusion: It involves multiple representations on a single biometric parameter. (ii) Single biometric multiple matching techniques: It incorporates multiple matching strategies in the matching module of a biometric system and combines the scores generated by these strategies. (iii) Multiple biometric fusions refer to the fusion of multiple biometric parameters. The three possible levels of biometrics fusion are: (i) *At feature extraction level:* The features of two or more biometric parameters are combined to generate new set of features by concatenation, arithmetic and logical operations. (ii) *At matching score level:* The matching scores are obtained from different biometric parameters and are fused by different techniques. (iii) *At decision level:* The resulting features from multiple biometric data are fused individually to classify either accept or reject.

Contribution- In this paper BBMFI model is proposed. The iris features are generated using DWT and DCT. The FFT and DWT are used to obtain features of fingerprint. The features of both iris and fingerprint are concatenated to generate final feature set for matching.

Organization- The paper is organized as follows. Section II presents related works. Section III describes background

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details. Section IV explains the proposed model. Section V explains the algorithm. Section VI gives the results and discussion.

II. Literature Survey

Mahdi S Hosseini and Hamid Soltanian-Zadeh [9] introduced an algorithm that encodes the pattern of pigment melanin in the Visible Light (VL) image, independent of textures in the Near-Infrared (NIR) image. It also extracts invariant features from VL and NIR images, whose fusion leads to higher classification accuracy. Jaishanker et.al., [10] proposed efficient algorithm for generating a Sectored Random Projections for Cancelable Iris Biometric. Atul Bansal Ravinder Agarwal and Sharma [11] proposed various algorithms in the different stages of iris recognition along with feature extractions and template matching technique namely supporting vector machine is analysed for iris recognition. Conti, et al., [12] proposed fingerprint recognition system uses pseudo-singularity points based on core and delta position, their relative distance and orientation to perform both classification and matching tasks.

III. BACKGROUND

DWT: It is a wavelet transformation for which the wavelets are discretely sampled. The key advantage of DWT over Fourier transformations is temporal resolution: it captures both frequency and time. DWT at each level is decomposed into low frequency (approximation) and high frequency band (horizontal, vertical and diagonal).

*DCT***:** It expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. The cosine is more efficient than sine functions, whereas for differential equations the cosines express a particular choice of boundary conditions. DCT is a Fourier-related transform similar to the Discrete Fourier Transform (DFT) using only real numbers.

FFT: The algorithms are the fundamental principle of decomposing the computation of discrete transformation of a sequence of length N into successive smaller DFT. The FFT algorithm is used to effectively reduce the computation time. The FFT algorithm provides a way to transform the current image from spatial space into frequency space. The FFT module will decompose an image into its fundamental intensity frequencies that can be filtered and recombined to create a new image. The main use of the FFT in image processing is for the removal of repetitive noise from an image.

IV. Model

In this section the definitions of performance parameters, proposed model and matching is discussed.

A. Definitions:

(i) False Rejection Rate (FRR): It is the measure of biometric security system that will incorrectly reject an access attempt by an authorized user is given in equation 1.

$$FRR = \frac{Number\ of\ Falsely\ rejected\ imajes}{Total\ number\ of\ persons\ in\ the\ database} \quad \text{---} (1)$$

(ii) False Acceptance Rate (FAR): It is the measure of biometric security system that will incorrectly accept an access attempt by an unauthorized user is given in equation 2.

$$FAR = \frac{Number\ of\ Falsely\ Accepted\ images}{Total\ number\ of\ persons\ out\ of\ database} \quad \text{----} (2)$$

(iii) Total Success Rate (TSR): is the probability that different images of the same biometric are matched is given in equation 3.

$$TAR = \frac{Number\ of\ correct\ matches}{Total\ number\ of\ persons\ in\ the\ database} \quad \text{----} (3)$$

(iv) Equal Error Rate (EER): the rates at which both accept and reject errors are equal.

(v) Euclidean Distance: It calculates a pairwise distance between two vectors, test vector against final dataset vector is shown in equation (4).

$$d(p,q) = d(q,p) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \cdots + (q_n - p_n)^2} = \sqrt{\sum_{i-2}^{n} (q_n - p_n)^2} \quad \text{--------} (4)$$

Where p is features of enrolment image and q is the features of test image.

B. Proposed model of BBMFI:-

The multiple transformations such as Discrete Wavelet Transformation (DWT), Discrete Cosine Transformation (DCT) and Fast Fourier Transformation (FFT) are used to generate features of fingerprint and iris. The features of fingerprint and iris are concatenated in the fusion process to generate final set of feature vector for bimodal biometric in the proposed model. The block diagram of BBMFI is as shown in the Fig.1.

*(i) Fingerprint database***-** DB3_A fingerprint images of persons are taken from FVC2004. DB3_A database is considered due to its high resolution and size compatibility. The database consists of 8 samples per person taken from a sensor at different timings. The fingerprint database is created by considering first 50 persons out of 100 persons and for each person first 7 samples are considered which leads to total of 350 fingerprint images in the database. The eighth sample of each person from first 50 persons is considered as test image to compute FRR and TSR. Ten persons who are out of database are considered to compute FAR.

*(ii) Iris database***-** Iris images of cooperative person are taken from the Chinese Academy of Sciences Institute of Automation (CASIA V1.0) database for each person having 7 samples of total 108 persons. The database images were collected using close-up iris camera in two sessions i.e., first three images in the first session and the next four images in the second session. Iris database is created by considering first 50 persons out of 108 persons and for each person first 6 samples are considered which leads to total of 300 iris images

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in the database. The seventh sample from first 50 persons is considered as test image to compute FRR and TSR. Ten persons who are out of database are considered to compute FAR.

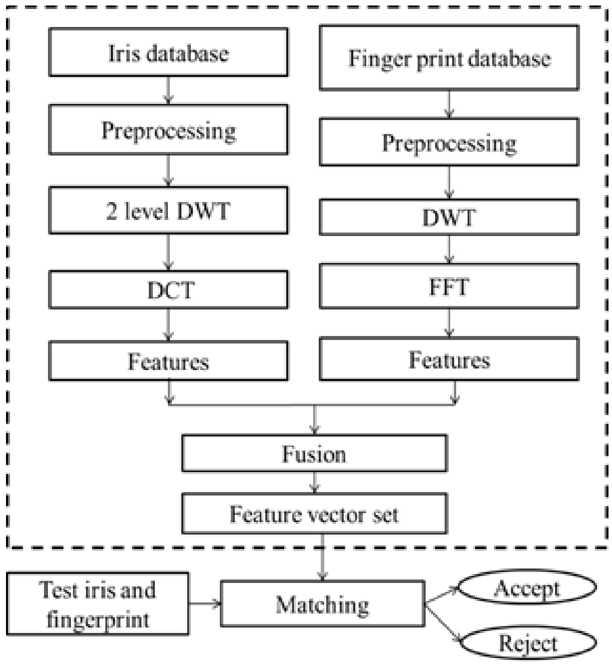

Figure 1. The block diagram of BBMFI

(iii) Iris Preprocessing- Each eye image is a greyscale image of size 280×320. The initial stage begins with locating the centre and radius of the pupil in order to separate the iris image [13]. The estimation efficiency of the pupil depends on computational speed rather than accuracy since it is simple in shape and is the darkest region in an eye image. It can be extracted using a suitable threshold. The Morphological process is used to remove the eyelashes and to obtain the centre and radius of the pupil and is shown in Fig.2 (a).

The basic morphological operations are dilation and erosion which use the structuring element to process the image. The structuring element with required dimension is used to remove the eyelashes. A structuring element is a matrix consisting of 1's and 0's which can have arbitrary shape and size and is typically smaller than the image being processed. The centre pixel of the structuring element is called the origin which identifies the pixel of interest in an image and the neighbouring elements are used to dilate or erode the image. Dilation adds pixels to the boundaries of an object in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element. In dilation and erosion operations, a rule is applied to the pixel of interest and its neighbours in an image. The rules are: (i) the origin of the structuring element identify the pixel of interest in the input eye image and the minimum value of all the pixels in its neighbourhood is assigned to the corresponding pixel in the output image is as shown in Fig.2(b). (ii)The origin of the structuring element identifies the pixel of interest in the input eye image and the maximum value of all the pixels in its neighbourhood is assigned to the corresponding pixel in the output image is as shown in the Fig.2(c).

Pupil Detection: Connected components labelling scans an image and groups its pixels into components based on pixel connectivity. All pixels in a connected component share similar pixel intensity values and are in some way connected with each other. Once all groups have been determined, each pixel in that group is labelled. The centre and the diameter of all the groups are determined and the one with the largest diameter is the pupil. Now the upper and lower portions of the iris occluded by eyelashes and eyelids are removed by setting all the pixels above and below the diameter of the pupil as Not a Number (NaN). According to the Springer analysis of the CASIA database [14], the lowest and highest iris radius is found to be 90 and 125. Based on this, 45 pixels to the left and right of the pupil boundary is considered as iris region as shown in Fig.2 (d).

Conventional iris recognition systems use edge detection techniques for localization like Hough circle for iris and pupil boundary detection and line detecting algorithms for eyelids. These methods involve excessive computation and hence are time consuming. However, morphological processing is used here which reduces the time required for preprocessing to a large extent. In the proposed method, iris normalization is avoided. From the localized image, the iris regions to the left and right of the pupil are selected and a template is created by mapping the selected pixels on a 60×80 matrix as shown in Fig.2 (e). Histogram equalization is done on each iris template to generate an image whose intensity levels are uniform and it also covers the entire range of intensity levels. The resulting image has high contrast as shown in Fig.2 (f).

(iv) Fingerprint Preprocessing: The original fingerprint image size of FVC2004, DB3_A is 480*300. The greyscale fingerprint image is converted into binary image by setting some threshold value to generate binary bits. With this operation, ridges in the fingerprint are highlighted with black colour and furrows with white [15]. The binarized image is cropped to a size of 430*220 to obtain Region of Interest (ROI).

(v) Iris Features: Two-level coiflet DWT is applied on iris template of size 75*60. The approximation band of second level DWT is considered having size of 22*18. DCT is applied on approximation band of second level DWT to derive DCT coefficients of iris template which forms iris features.

$$y(k) = w(k)\sum_{n=1}^{N} x(n)\cos\frac{\pi(2n-1)(k-1)}{2N}$$

for k=1 … N … (5)

$$\text{where } w(k) = \begin{cases} \frac{1}{\sqrt{N}}, & k=1 \\ \sqrt{\frac{2}{N}} & 2\le k\le N \end{cases}$$

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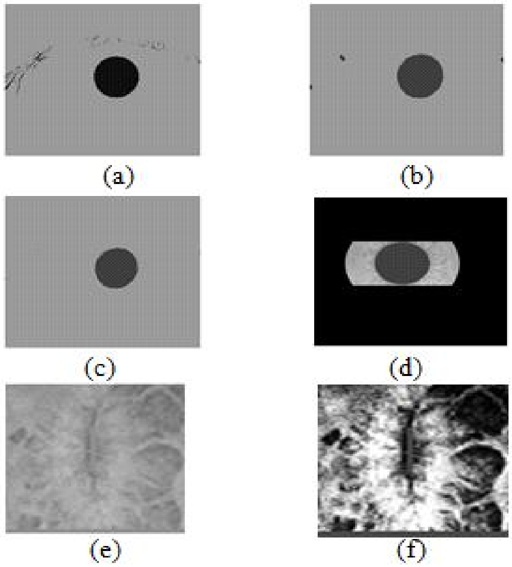

Figure 2. (a) Extracted pupil (b) dilation (c) erosion (d) after removing upper and lower iris regions (e) segmented iris (f) iris template

N is the length of x, and x and y are the same size. If x is a matrix, DCT transforms its columns. The series is indexed from n = 1 and k = 1 instead of the usual n = 0 and k = 0 because vectors run from 1 to N instead of from 0 to N- 1.

(vi)Fingerprint Features: ROI of fingerprint is segmented into four cells to improve recognition rate. Single level DWT is applied on each cell [16]. The FFT is applied on approximation band of each cell to generate FFT coefficients. The absolute values of FFT coefficients of each cell are computed to form fingerprint features.

C. Matching

The probability of matching a person with a different person is high with single biometric such as iris and fingerprint. The fusion of two biometric parameters reduces the probability of matching with different persons. The features of iris and fingerprint are fused using concatenation to generate final feature vector for accurate recognition of person [17]. The Euclidean distance is used for the comparison between final features vector set with final feature vector set of test images for matching.

V. Algorithm

The proposed algorithm is used to authenticate a person effectively by fusion of iris and fingerprint features.

The objectives are as follows:

1. To fuse features of two biometric i.e. iris and fingerprint.
2. To reduce FAR and FRR.
3. To increase success rate of verification.

The Table 1 gives an algorithm of proposed model in which two biometric features are concatenated to get better performance results.

Table I
Proposed algorithm

Input: Fingerprint database, Test fingerprint, Iris database, Test iris
Output: Verification of person
1. Read iris and fingerprint images
2. Iris is preprocessed using morphological structuring element method and histogram equalization is applied
3. 2-level DWT is applied on iris template
4. DCT is applied on approximation band to generate features of iris
5. Fingerprint is preprocessed
6. DWT is applied on fingerprint template
7. FFT is applied on approximation band to generate features of fingerprint
8. The features of iris and fingerprint are fused by concatenation
9. Repeat step 1 to 8 for test iris and test finger
10. Test features are compared with database features using Euclidean distance

VI. Results and Discussion

For performance analysis CASIA V1.0 iris database and FVC2004 DB3_A fingerprint database are considered. The two sets of database are created by considering iris and fingerprint of 10 persons and 50 persons with 6 samples per person, the seventh sample of each person is considered as test image, which is used to compute FRR and TSR. The FAR is computed by considering 10 persons which are out of database created with 10 and 50 persons. The Table 2 shows the values of FRR decreases from 100% to 8% as threshold increases. The values of TSR and FAR is increased with threshold in the case of iris parameters.

Table II
FRR, TSR and FAR variation with Threshold for iris

Threshold	FRR (%)	TSR (%)	FAR (%)
1.0	100	0	0
1.5	98	2	0
2.0	80	20	0
2.5	38	62	0
3.0	8	92	10

The Table 3 shows the values of FRR decreases from 100% to 14%, TSR increases from 0% to 86% as threshold value increases from 1.0 to 8.0 with constant zero value of FAR for fingerprint. The Table 4 shows the values of FRR decreases from 100% to 2%, TSR increases from 0% to 98% as threshold values varies between increases 1.0 and 8.2 with constant zero value of FAR for fusion of fingerprint and iris.

Table III
FRR, TSR and FAR variation with Threshold for fingerprint

Threshold	FRR (%)	TSR (%)	FAR (%)
1.0	100	0	0
2.0	100	0	0
3.0	100	0	0
4.0	100	0	0
5.0	100	0	0
6.0	72	28	0
7.0	18	82	0
8.0	14	86	0

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TABLE IV
FRR, TSR AND FAR VARIATION WITH THRESHOLD FOR FUSION

Threshold	FRR (%)	TSR (%)	FAR (%)
1.0	100	0	0
2.0	100	0	0
3.0	100	0	0
4.0	100	0	0
5.0	100	0	0
6.0	98	2	0
7.0	62	38	0
8.0	8	92	0
8.1	8	92	0
8.2	2	98	0

The Table 5 shows the results for 50 persons taken from database for computing FRR and 10 persons are considered from out of database for computing FAR. The value of FRR is more in the case of unimodal compared to bimodal technique. The value of FAR is zero in the case of bimodal compared to unimodal.

TABLE V
FRR AND FAR OF PROPOSED BBMFI SYSTEM FOR 50 PERSONS

Biometric system	FRR (%)	FAR (%)
Unimodal Iris	8	10
Unimodal Fingerprint	14	0
Bimodal	2	0

The variations of FAR and FRR with threshold for BBMFI is shown in the Fig.3. The FRR decreases as threshold increases whereas FAR increases with threshold. The value of EER is 2%.

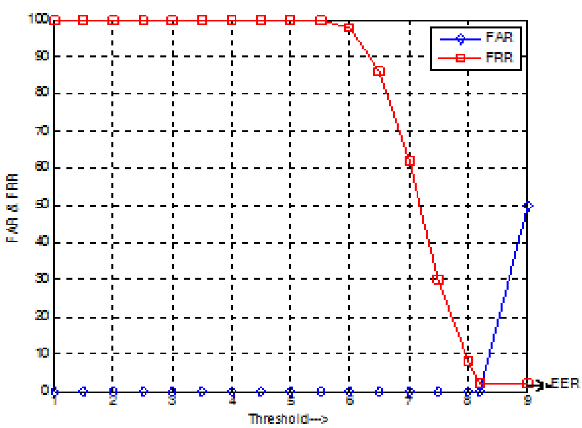

Figure 3. FAR and FRR vs Threshold for BBMFI

The values of FRR for unimodal and BBMFI with threshold are compared in the Fig.4. The FRR decreases as threshold increases for unimodal and BBMFI technique. The value of FRR is low in the case of proposed BBMFI technique compared to unimodal technique since the features of iris and fingerprint are fused.

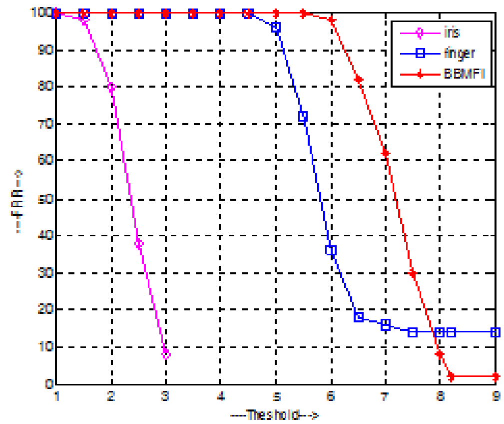

Figure 4.FRR vs. threshold for unimodal and BBMFI

The variation of FAR with threshold for iris, fingerprint and bimodal i.e. BBMFI are shown in the Fig.5. The value of FAR increases as threshold increases. The value of FAR is zero in the case of proposed algorithm compared to individual biometric iris and fingerprint.

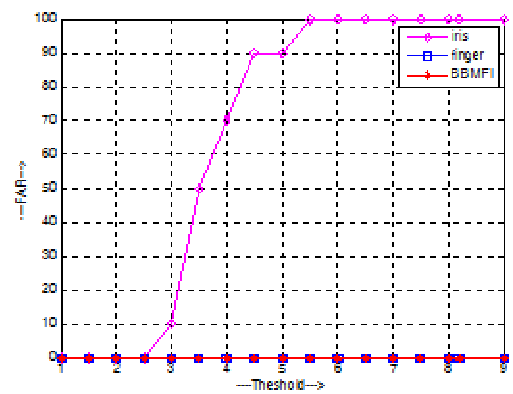

Figure 5.FAR vs threshold for unimodal and BBMFI

The percentage values of FRR and FAR for 10 persons are given in the Table 6 for the existing technique A Frequency-based Approach for Features Fusion in Fingerprint and Iris Multimodal Biometric Identification Systems (FBA) [18] and the proposed technique BBMFI. The value of FRR is more in the case of unimodal compared to bimodal technique. The value of FAR is 0% in the case of bimodal compared to unimodal technique. It is observed that the values of FRR and FAR are improved in the case of proposed algorithm compared to the existing algorithm.

TABLE VI
COMPARISON OF FRR AND FAR OF FBA AND BBMFI SYSTEM FOR 10 PERSONS

Biometric system	Existing FBA [29]		Proposed BBMFI	
	FAR(%)	FRR(%)	FAR(%)	FRR(%)
Unimodal Iris	0.67	9.98	0	0
Unimodal Fingerprint	1.35	16.78	0	0
Bimodal	0	5.71	0	0

CONCLUSION AND FUTURE WORK

Bimodal biometrics provides better recognition compared to unimodal. In this paper BBMFI model is proposed by combining fingerprint and iris features. Two level DWT is

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applied on preprocessed iris template and DCT is used on low frequency band to generate features of iris. The fingerprint image is preprocessed to obtain ROI then divided into four cells. Each cell is applied with DWT and FFT to generate feature of fingerprint. The features extracted from fingerprint and iris is concatenated to generate final feature vector set. The final decision of recognition is made using Euclidean distance on the test features vector and final features vector of database. Thus proposed bimodal biometric system achieves better results. In future the algorithm is tested using different kinds of transformation and fusion techniques with different databases to improve the performance parameters.

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